keys to a continent

the great lakes

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keys to a continent

Brave men came to this continent seeking a new way to the riches of the East. Instead they found another source of wealth that ranks as one of the natural wonders of the earth. This is the glistening chain of freshwater inland seas we call the Great Lakes.

Born during the last ice age, today these lakes are keys to the continent's vast interior. Their waters are the life-blood of its industrial heartland, supporting close to 35 million people around their shores. Among them are more than seven million Canadians—about a third of Canada's whole population.

From Duluth on Lake Superior to Kingston at Lake Ontario's outlet—some 800 miles to the east—scores of bustling municipalities depend on the lakes' abundant waters. These include some of North America's biggest cities, like Chicago, Detroit, Cleveland, Buffalo, Toronto and Hamilton. Canada's largest metropolis, Montreal, receives most of its water from the Great Lakes via the St. Lawrence River. So do Quebec, Trois Rivières and other St. Lawrence River communities.

Besides supplying millions of homes, farms and factories, the lakes provide water for cheap electrical power. Far from any ocean, they are highways for the low-cost shipment of wheat, coal, iron ore, petroleum, manufactured goods, and other commodities. They support valuable fisheries and serve as playgrounds for countless pleasure-seekers.

To the early pioneers and the Indians before them, the Great Lakes were a bountiful resource. But they have never been more precious than today, when too many of us take them for granted.

a wealth of water

These enormous natural reservoirs hold nearly a fifth of the world's fresh liquid surface water. Their total volume, some 5,500 cubic miles, is less than the 6,300 cubic miles in southern Siberia's Lake Baikal; but their surface area, about 95,000 square miles, far exceeds Lake Baikal's 12,000 square miles.

Together the Great Lakes have a larger area than Pennsylvania and New York State combined. This is slightly less than that of Canada's three Maritime Provinces plus the island of Newfoundland, but greater than the total area of England, Scotland, Wales and Northern Ireland.

Lake Superior alone—the world's biggest expanse of fresh water—is larger than all of Scotland or the combined provinces of New Brunswick and Prince Edward Island.

If we could stop all the rivers flowing into Lake Superior, and also the rain and snow, it would take about 186 years to run dry.

(It would be necessary, of course, to raise the lake bottom to the level of its outlet, the St. Mary's River. Lake Superior's greatest known depth is 1,333 feet—733 feet below sea level.)

So large are the Great Lakes that they influence the climate. Without them the whole region would suffer the usual extremes of a "continental" climate—very hot summers and very cold winters. But the lakes have a cooling effect in summer and a warming effect in winter. This is because large bodies of water absorb heat slowly during the summer, then release it slowly during the winter.

This moderating effect is greater on the lee shores of the lakes. However, those areas also have more severe storms, which pick up energy and moisture as they cross the water.

a dependable supply

The lakes' enormous storage capacity assures a steady, almost uniform flow in their outlet rivers. Many other rivers may be gentle streams or surging torrents, depending on the weather. The Great Lakes, however, provide a relatively constant flow despite heavy rains or droughts.

The lowest recorded flow in the St. Lawrence River is about one-half the maximum. By contrast, the Columbia River's lowest recorded flow at Trail, British Columbia, is only one-fortieth the maximum. In many other Canadian rivers the maximum flow may range from five to 150 times the minimum.

The levels of the Great Lakes do vary to some extent, along with the flows of their outlet rivers. Only occasional-

ly, though, does this cause serious flooding or other problems. Compared to changes in other lakes and rivers, those in the Great Lakes are small indeed.

With present controls, the level of Lake Superior varies only about one foot in an average season. The same is true of Lakes Huron and Michigan. The two smaller lakes show slightly wider variations, averaging 1.2 feet in Lake Erie and 1.5 feet in Lake Ontario.

The Great Lakes cover nearly a third of their entire drainage basin—some 95,000 square miles of the total 295,000. Such a large proportion is most unusual. In many other drainage basins only a tenth or less of the total area is covered by water.

the moving barrier

Scientists have discovered another remarkable feature of these lakes, known as the *thermal bar.* This is a line of sharp temperature difference, often marked by bits of driftwood, dead fish and other debris. On the warmer side the water is often cloudy or muddy, while that on the colder side is clear.

Thermal bars appear in spring, dividing the warmer inshore waters from the cold main body of the lake. As the season advances they move toward the centre, disappearing in early summer. More than a mere curiosity, they are important to our understanding and control of pollution.

Along the thermal bar the water is denser and heavier, resisting any movement by the warmer inshore water. Thus it forms a barrier to polluting substances from the land, holding them close to shore. There the pollution may concentrate, unable to disperse throughout the lake.

In spring the chilly water in the centre of the lake is also

dense and heavy. But the densest, heaviest water is along the thermal bar itself, where the temperature is slightly higher—about four degrees centigrade. This is because water contracts as it cools toward that temperature, then starts to expand again as it cools further.

early exploration

We shall never know who were the first human beings to see the Great Lakes. But the earliest-known European explorers were French. Samuel de Champlain reached the Georgian Bay area of Lake Huron in 1615, after ascending the Ottawa River.

Later that year Champlain and Étienne Brulé discovered Lake Ontario, and Brulé probably saw Lake Superior in 1622. Jean Nicolet visited Lake Michigan and Green Bay in 1634, after exploring Lake Huron's North Channel. In 1659 Pierre Radisson and Médard des Groseilliers travelled on Lake Superior.

Lake Erie was the last of the Great Lakes discovered by the French, partly because the hostile Iroquois Indians controlled the lower lakes. Jesuit missionaries probably visited Lake Erie around 1650. Two Sulpician priests, Father René Bréhant De Galinée and François Dolliers de Casson, spent the winter of 1669-1670 on Erie's northern shores near Port Dover.

In 1673-1674 Louis Jolliet explored Lake Michigan extensively with a Jesuit priest, Father Jacques Marquette. In 1679 René Robert Cavelier de La Salle sailed Lakes Erie, Huron and Michigan aboard the *Griffon,* the first sailing vessel on the Great Lakes. The *Griffon* was lost with a cargo of furs after La Salle and his party left the ship.

gift of the glaciers

14,000 years ago

13,000 years ago

But the lakes have an older, longer history which geologists are still deciphering from ~~the earth's own records~~.

The Great Lakes are a gift of the glaciers that covered half the continent during the last ice ages. The latest of these began about 100,000 years ago when the huge Laurentide Ice Sheet pushed outward from northeastern Canada. As it melted away from its southern limits between 10,000 and 15,000 years ago it left behind our magnificent lakes.

At some places the Laurentide Ice Sheet was 5,000 to 10,000 feet thick, burying the tops of mountains. So enormous was its weight that the earth's crust sank beneath the load as much as several hundred feet. Meanwhile, rock fragments held in the ice acted like cutting tools—scraping, gouging, chiselling and resculpturing the landscape.

The grinding glacier scoured out ancient valleys, making them deeper and wider. It carried rocks, soil and gravel to new locations, building up young hills and ridges that frequently blocked old drainage channels. So were formed a series of broad, deep basins, further depressed by the weight of the ice. These filled with water as the ice sheet melted.

The edge of the ice made several smaller retreats and fresh advances, creating and re-creating a splendid array of glacier lakes. The same sort of thing had occurred in earlier ice ages, starting perhaps a million years ago. After the last ice age, known as the Wisconsin, the Great Lakes took their present form.

We see clear traces of earlier lakes in wave-cut cliffs and abandoned shorelines, in ancient bottom deposits, sand bars and beaches far from present shores. These tell us of many changes in the form and extent of the lakes, which used to drain to the southwest or southeast.

the changing map

12,500 years ago

11,500 years ago

As the glaciers retreated northward, large lakes first were formed in the southern part of the Great Lakes basin. During the last ice age the earliest of these was Lake Maumee, in the western part of the Lake Erie basin. Formed about 14,500 years ago, Lake Maumee drained southwestward to the Mississippi River. So did Lakes Chicago and Keweenaw, in the Michigan and Superior basins. Some of the lakes created during the Wisconsin age were even larger than those we have today. Lake Warren covered the present Lake Erie basin and also much of Lake Huron's. Lakes Huron and Michigan are descendants of Lake Algonquin, which was bigger than both together.

At times the upper lakes emptied into the Lake Ontario basin through the Trent River valley. At other times they drained by way of North Bay directly to the sea, which then extended up the St. Lawrence and Ottawa valleys.

The Great Lakes' present outlet, the upper St. Lawrence River, became free of ice about 12,000 years ago. Before finding its present path to the ocean—possibly 6,000 years ago—the St. Lawrence drained southward by way of the Hudson River.

Many natural forces produced these changes. Among them were the direct reshaping of the land by the glaciers and the damming of lakes and streams by glacial ice. Another was the action of rivers in cutting new channels and deepening old ones. Still another was crustal movement—the slow rebounding of the earth's crust after being pressed down by the tremendous weight of ice.

Like the surface of a huge rubber ball, the Great Lakes region is still recovering from this burden. Although more slowly than before, the earth is rebounding faster in the northeastern part of the basin than in the southwest. Consequently, water levels with respect to land are falling about 10 inches per century in Georgian Bay, but rising about three inches per century at Chicago.

what lies ahead ?

Someday, after many thousands of years, the Great Lakes will probably die and disappear. This seems to be the fate of all the world's lakes, which endure for only a moment in the earth's long history.

From the time they are formed, lakes start to fill with sediment from inflowing streams. Plant growth hastens this process, adding organic material to other deposits. This can transform shallow lakes into marshes, swamps and bogs which presently become dry land. This could happen to Lake Erie, the shallowest of all the Great Lakes. Thick masses of primitive plants called algae have recently appeared there, carpeting many square miles of the lake.

9,500 years ago

Among them are blue-green algae like *Oscillatoria* and *Anabaena,* which form long strands on the surface of the water. Another nuisance is *Cladophora,* a foul-smelling green alga which grows on the lake bottom and on rocks, piers and gravel along the shores.

Some kinds of algae are used for food, while some have other uses—in treating sewage, for example. But no one has yet found a use for these offending varieties in Lake Erie and other lakes. On the contrary, they threaten the lakes with premature death—and man himself is largely to blame.

The growth of these troublesome plants is spurred by the phosphorus and other nutrients in sewage and other wastes. On our farms such chemicals are used as fertilizers to grow abundant crops. In the lakes they have a similar effect—but the crops are unwanted algae.

spoiling a lake

This over-fertilization of the lakes is known as *eutrophication.* Today it is a serious pollution problem—perhaps the most serious problem facing us on the Great Lakes. Unless we can control it soon, the cost will be much greater later on.

Besides choking large areas of lake surface, slimy masses of algae wash up on the beaches and rot there. They clog water intakes and produce unpleasant tastes. Out from shore, as they die they sink to the bottom and decay, fouling the spawning beds of valuable fish.

In the process of decay algae use up large amounts of oxygen in the lake's lower depths—oxygen needed by fish for breathing. In summer, as the lake surface warms up, this oxygen is not easily replaced.

Being less dense and lighter, the warmer water stays at the surface, hardly mixing with the cool water below. This restricts any upward circulation of the deeper water, and so prevents it from absorbing fresh oxygen from the atmosphere. In summer, therefore, the bottom water becomes steadily depleted of its oxygen by decaying algae.

In Lake Erie this summer oxygen depletion has grown more serious as pollution has increased. Over the whole central basin of the lake, the rate of this depletion has doubled over the past 30 years. One result is that many desirable species of fish have almost vanished from the lake.

a spreading problem

Moreover, Lake Erie is not the only one affected by eutrophication. Algae are multiplying elsewhere in the Great Lakes, especially in parts of Lakes Ontario and Michigan. Because of their greater volume of water, pollution in those lakes is not yet so serious as in Lake Erie. But it soon could become so if we neglect it.

Least polluted are Lakes Superior and Huron, both because of their size and because they have less industry and fewer people around their shores. As our industries and population grow, however, we cannot be complacent even there.

What are the sources of the plant nutrients responsible for this problem? In Lake Erie 72 per cent comes from municipal sewage, especially detergents. Detergents contribute about two-thirds of the phosphorus in sewage, or nearly half of the lake's total input.

Another 17 per cent is washed into the lake from farms, and about seven per cent from city streets and other urban property. Four per cent comes from industrial wastes.

Ordinary sewage treatment does not remove plant nutrients from waste water. In some places, though, special treatment methods have been developed to remove much of the phosphorus. Such methods might play an important part in saving the Great Lakes.


ALBANY RIVER
OGOKI R.
OGOKI DIVERSION
KENOGAM
LAKE NIPIGON
LONG LAKE
PORT ARTHUR
FORT WILLIAM
LAKE SUPERIOR
DULUTH
LAKE MICHIGAN
DET
CHICAGO
CHICAGO SANITARY AND SHIP CANAL


great lakes
drainage basin
SCALE OF MILES
50
0
50
100
R.
VERSION
ULT STE. MARIE
GEORGIAN
BAY
LAKE
HURON
KINGSTON
TORONTO
LAKE ONTARIO
BURLINGTON
HAMILTON
AKE
CLAIR
BUFFALO
LAKE ERIE
CLEVELAND

Heavy traffic in the Welland Canal

canals and shipping

Over more than a century, men have made other changes in the Great Lakes system. The earliest of these—and some of the latest—were to aid navigation. Great Lakes shipping now totals close to 200 million tons a year, chiefly grain and iron ore.

Among the world's busiest canals are those at Sault Ste. Marie on the St. Mary's River, between Lakes Superior and Huron, and the Welland Ship Canal between Lakes Erie and Ontario. These are vital links in the Great Lakes-St. Lawrence Seaway, which carries ocean-going vessels more than 2,300 miles from the Atlantic.

At Sault Ste. Marie the old North West Company built a two-foot-deep canal in 1797-1798 on the north side of the rapids. The State Canal was constructed on the United States side in 1853-1855. The present Canadian lock was built after 1870, when a British military supply ship was barred from the American canal.

The Welland Ship Canal, 27.6 miles long, crosses the Niagara Peninsula from Port Colborne on Lake Erie to Port Weller on Lake Ontario. Completed in 1932, it replaced a privately-built canal first opened in 1829. This ended at Port Dalhousie, about three miles west of Port Weller. As we shall see, this old canal opened a way for the dreaded sea lamprey into the upper lakes. Only recently have we learned how to control this scourge of the Great Lakes fishing industry.

Millions of dollars are spent each year maintaining harbors and shipping channels in the Great Lakes system. Since the St. Lawrence Seaway was completed in 1959, these channels have been dredged to a minimum depth of 27 feet.

diverting the waters

The Chicago Sanitary and Ship Canal links the Chicago and the Des Plaines River, a part of the Mississippi system. Opened in 1900, it diverts water from Lake Michigan into the Mississippi; but since 1938 the amount has been drastically limited by decrees of the United States Supreme Court. Some of it is used to generate power at Lockport and Marseilles, Illinois.

This loss to the Great Lakes is more than made up by two diversions into Lake Superior from the James Bay watershed. These are the Long Lake and Ogoki River diversions, controlled by the Ontario Hydro-Electric Power Commission.

Long Lake normally drains into James Bay through the Kenogami and Albany Rivers in Northern Ontario. But since 1939 its flow has been diverted through a series of small lakes into the Augusabon River, a tributary of Lake Superior. Ontario Hydro has a power development on this river.

The Ogoki River, another tributary of the Albany, was diverted into Lake Nipigon in 1943. From Lake Nipigon the water is released to operate power plants on the Nipigon River, Lake Superior's largest tributary.

The Ogoki diversion was temporarily stopped during June and July of 1952, when record high levels caused flooding around the Great Lakes.

An earlier, smaller diversion was the Illinois and Michigan Canal, opened in 1848 and abandoned in 1910. This extended from the Chicago River at Chicago to the Illinois River at La Salle, Illinois. It drew water partly from the Chicago River and partly from the Calumet River.

what changes lake levels ?

But such diversions have only a small effect on lake levels, compared to those produced by prolonged changes in the weather. Such changes caused record high levels in 1952 and record low levels in 1964—only 12 years later.

The greatest amount diverted through the Chicago Sanitary and Ship Canal was only 10,000 cubic feet per second—about three times the present amount. But an inch less rainfall over the drainage basin of Lakes Michigan and Huron in a year reduces their supply by 16,400 cubic feet per second.

Annual average precipitation in this area is about 30 inches. Over the whole Great Lakes basin it is 32 inches. The Great Lakes are fed almost entirely by the rain and snow that fall in this basin. But not all of this reaches the lakes, and still less is finally discharged from Lake Ontario into the St. Lawrence River.

More than two-thirds is consumed by evaporation directly into the air and by transpiration from plants. Besides that evaporated off the land, large amounts of water evaporate from the surfaces of the lakes and their tributary streams.

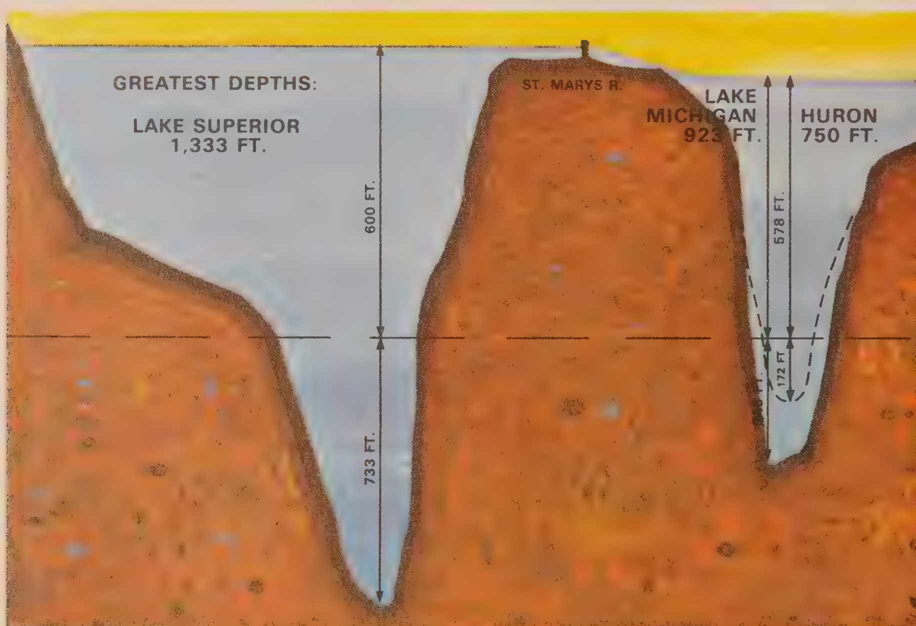
Lake levels vary with the changing seasons. Melting snow and low evaporation cause them to rise in spring, usually reaching their highest point in early summer. Increased evaporation and plant transpiration lower them in summer and fall. Water-level changes are more irregular in winter, because of the piling up and melting of snow.

Because of the vast size of the Great Lakes, large amounts of extra rainfall are needed to raise their levels appreciably. Moreover, because their outlet rivers have a limited capacity, periods of drought may also have little effect upon them. Over several years, however, abnormal weather can have a serious effect.

controlling the lakes

But the size of the lakes also makes them difficult to control. Suppose, for example, that we wanted to raise the level of Lake Superior by one foot. To do this we should have to add another 5,000 cubic feet per second for 5½ years—without losing a drop through the St. Mary's River. Farther down the system, the full effects of changes in Lake Superior may not be felt for many years. It takes about three years for just *half* an increase in Superior's outflow to reach the outlet of Lake Ontario. This is because an enormous volume of water is needed first to raise the levels of Lakes Michigan, Huron and Erie.

But a lot can happen in three years. Prolonged heavy rains could cause flooding around Lake Ontario and other parts

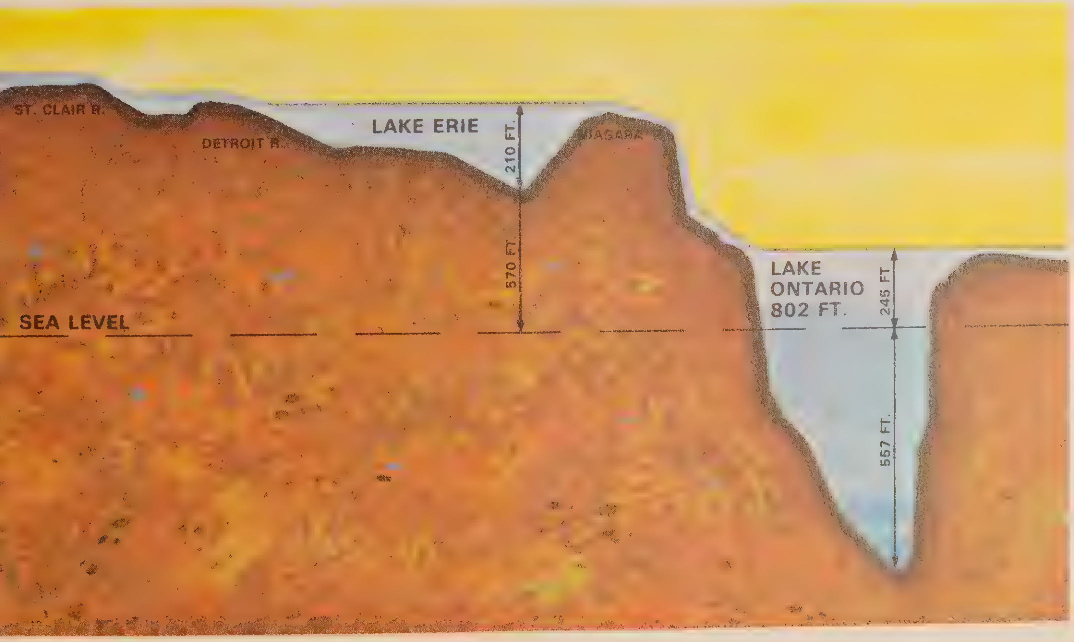


of the system. Then water diverted into Lake Superior a few years earlier would make the problem even worse.

We might overcome this difficulty if we could forecast the weather several years ahead. Someday, of course, this may be possible. But engineers now rely on dams, sluices and other such works to control the levels on individual lakes.

By international agreement, such control works now regulate the levels on Lake Superior and Lake Ontario. Similar controls have also been proposed for Lake Michigan-Huron (regarded as a single lake) and for Lake Erie.

Water levels on Lake Superior have been controlled since 1921 by works at Sault Ste. Marie in the St. Mary's River. Since 1958, Lake Ontario levels have been controlled by power works in the St. Lawrence River at Cornwall, Ontario. Twenty-five miles upstream, the Iroquois Dam provides alternative controls.



Niagara Horseshoe Falls

managing Niagara Falls

Control works in the Niagara River are used to regulate not Lake Erie, but the flow over Niagara Falls. Water from above the falls is diverted to run power plants on both sides of the river; but the amount is limited by the Niagara Diversion Treaty of 1950, which preserves the falls as a tourist attraction.

During the daylight hours of the tourist season, the flow over Niagara Falls must be maintained at no less than 100,000 cubic feet per second. At other times, however, it may be reduced to half that amount.

The Niagara River was used for water power as far back as 1725. The falls themselves were first used in 1853, by a small mill on the United States side which presently failed. Successful exploitation of the falls began in the United States in 1877. On the Canadian side, water for power was first diverted in 1893.

Canadian power plants using the Niagara River have a total capacity of some 2,277,000 kilowatts. Those on the United States side have a slightly smaller capacity—about 2,194,000 kilowatts.

solving problems together

Since 1909, Canada and the United States have regularly worked together to solve their common problems in the Great Lakes. That year they signed the Boundary Waters Treaty, under which the International Joint Commission was established.

Members of this commission are appointed by the Canadian and United States governments. It has jurisdiction over projects affecting waters along the Canada-United States border, and also waters flowing across that border. It is concerned not only with regulating water levels and river flows, but also with such problems as pollution.

Aiding the commission are the scientific and engineering staffs of government agencies in both countries—state and provincial as well as federal. In Canada these include the Department of Energy, Mines and Resources, the Department of National Health and Welfare, the Fisheries Research Board and the Ontario Water Resources Commission.

At Burlington, Ontario, is the Canada Centre for Inland Waters, a major research establishment of the Department of Energy, Mines and Resources. In this centre is the headquarters of the Great Lakes Division of EMR's Inland Waters Branch. But other agencies also use its facilities.

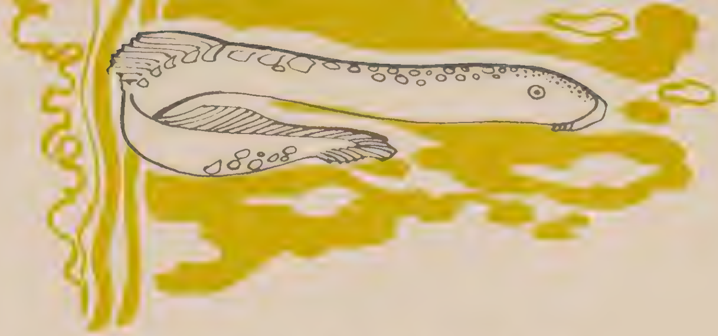
The department's Marine Sciences Branch operates a small fleet of research vessels in support of the Great Lakes program. These are used for continuing studies of pollution, as well as for research in lake-bottom geology, biology, water circulation, temperatures, ice formation and other characteristics of the lakes.

Other studies are concerned with such problems as changing water levels, shore erosion and flooding. Although floods are few and small around the Great Lakes, they

CSS Limnos: *part of EMR'S Great Lakes fleet*

still can cause heavy losses. This is because the shores of these lakes are so heavily built upon with homes, industries, port facilities and other installations.

Low water levels can be costly, too. By reducing the depth of shipping channels they can force large vessels to carry lighter cargoes. They can also leave wharves and boathouses stranded, to the annoyance of cottage owners and the operators of tourist resorts. In some places abnormally low levels may interfere with water-supply intakes.



saving the fisheries

Agencies like the Fisheries Research Board are seeking ways to protect and assist the Great Lakes fishing industry. Close to 100 million pounds of fish—sometimes more—are caught in the lakes each year. Almost half of this is taken from Canadian waters. The catch includes perch, smelts, yellow pickerel, whitefish, tullibee, white bass and lake herring.

Man's activities have struck two serious blows at our Great Lakes fisheries. One was opening an invasion route for the sea lamprey from Lake Ontario into the upper lakes, by way of the old Welland Canal. The other is the continuing pollution of the lakes, making them unsuitable for many desirable types of fish.

The sea lamprey is an eel-like parasite with a rasping, circular mouth that sucks the life from fish. It entered Lake Erie about 1921, and within a few decades had almost wiped out the trout and whitefish in Lakes Huron, Michigan and Superior. But it now has been controlled by a special poison used in the streams where it spawns.

Water pollution has struck hardest at Lake Erie fisheries, the richest in all the Great Lakes. Lake Erie once produced millions of dollars worth of whitefish, walleye, ciscoe and blue pike. But most of the catch today consists of less valuable fish like smelt and perch.

Pollution spoils the lakes for human beings as well as fish. It imperils our health, ruins our beaches and makes the water unfit for recreation, home or industrial use. Controlling pollution is expensive—but *not* controlling it could be disastrous.

We know today that we cannot take the lakes for granted. If we wish to go on using and enjoying them, we must use them wisely and carefully.

a close-up of the great lakes

Lake Superior is 350 miles long and 160 miles wide, covering 31,700 square miles. Of this expanse, 11,100 square miles are in Canada. Lake Superior's estimated volume is 2,858 cubic miles and its average depth about 487 feet.

Superior's nearest rival in area is Lake Victoria, East Africa, covering 26,828 square miles. But Lake Victoria's greatest known depth is only 270 feet, compared to Superior's 1,333 feet.

Two other Great Lakes, Huron and Michigan, rank third and fourth in area among the world's freshwater lakes. Their combined area is bigger than Lake Superior's, but their total volume is much less.

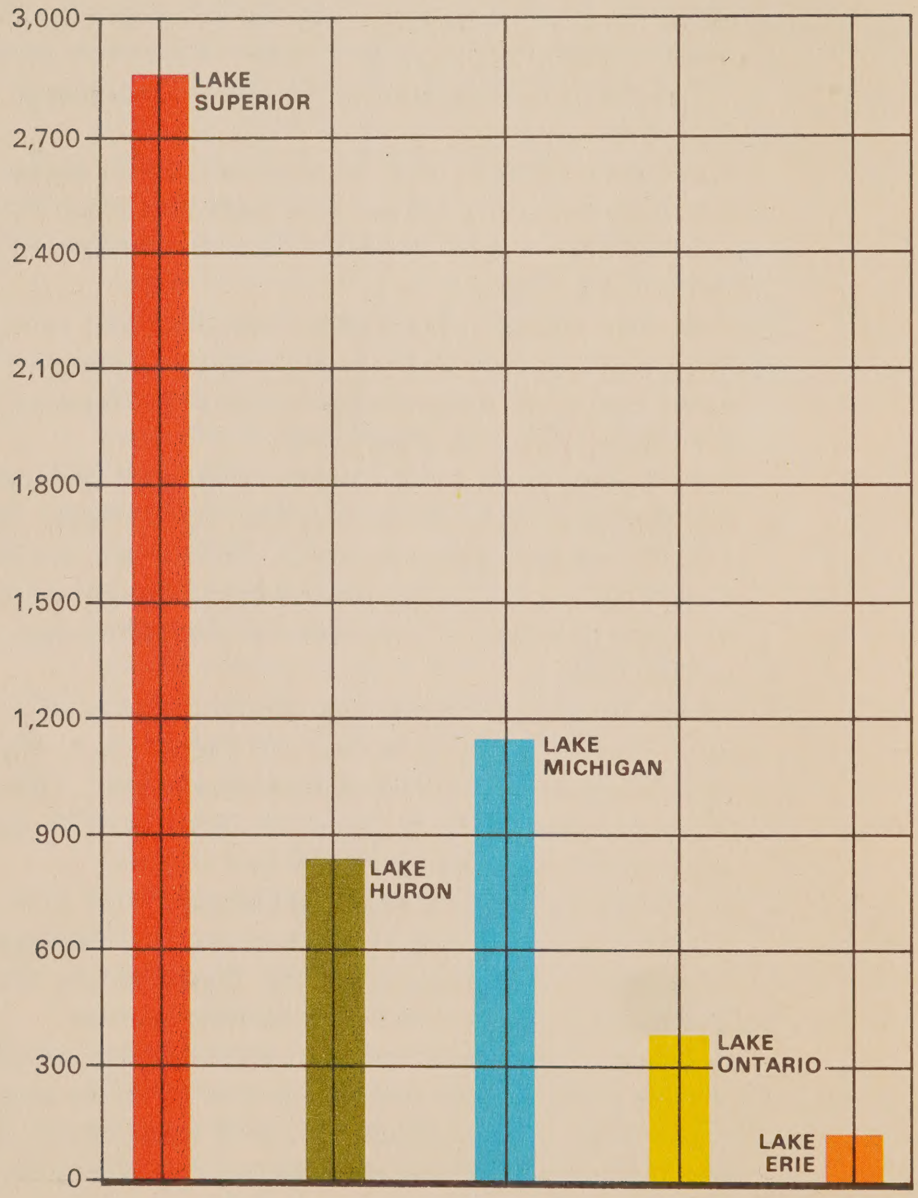
Lake Huron is 247 miles long and 101 miles wide, excluding Georgian Bay. Its area (including Georgian Bay) is 23,000 square miles, of which 13,900 are in Canada. Huron has an estimated volume of 824 cubic miles and an average depth of 195 feet. Its greatest known depth is 750 feet.

Lake Michigan, entirely in the United States, is 307 miles long and 118 miles across its widest part. Covering 22,300 square miles, it contains an estimated 1,166 cubic miles of water with an average depth of 276 feet. Its greatest known depth is 923 feet.

Linked by the broad Straits of Mackinac—four miles wide at their narrowest point—Lakes Huron and Michigan behave as a single body of water. Consequently they are treated as just one lake in engineering studies.

Smallest of the Great Lakes in area (but not in volume) is Lake Ontario, 193 miles long and 53 miles across its widest part. Of Lake Ontario's 7,340 square miles, 3,880 are in Canada. Its estimated volume is about 393 cubic

COMPARISON OF
GREAT LAKES VOLUMES
IN CUBIC MILES



miles, averaging 282 feet deep. Its greatest known depth is 802 feet.

Smallest in volume is Lake Erie, shallowest of the Great Lakes, 241 miles long and 57 miles wide. Erie's 116 cubic miles of water cover 9,910 square miles, of which 4,930 are in Canada. Its average depth is only 60 feet and its greatest depth 210 feet.

Except for Lake Erie, the deepest parts of all the Great Lakes are well below sea level. Lake Superior's greatest known depth is 733 feet lower—the deepest point in all the lakes. Lake Erie's maximum depth, however, is 361 feet *above* sea level.

Between Lakes Huron and Michigan is Lake St. Clair, a shallow widening of the St. Clair River. Lake St. Clair, 26 miles long and 24 miles wide, has an area of 430 square miles. Its greatest natural depth is only 21 feet, but a ship channel has been dredged to a depth of 27 feet.

Lake Superior's surface is 600 feet above sea level. At the other end of the chain, Lake Ontario's mean elevation is about 245 feet. Most of the drop—326 feet of it—occurs in the 28 miles of the turbulent Niagara River, which plunges 167 feet over Niagara Falls.

Draining Lake Superior is the St. Mary's River, 63 miles long, which tumbles over the mile-long rapids at Sault Ste. Marie for a drop of 20 feet. With a further drop of some two feet, this brings it to the level of Lakes Huron and Michigan, about 578 feet above sea level.

Other connecting rivers are the St. Clair, 38 miles long, which drains Lake Huron into St. Clair; and the Detroit, 32 miles long, draining Lake St. Clair into Lake Erie. In the more than 85 miles from Lake Huron to Erie the water level falls only eight feet—to Lake Erie's 570 feet above sea level.

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